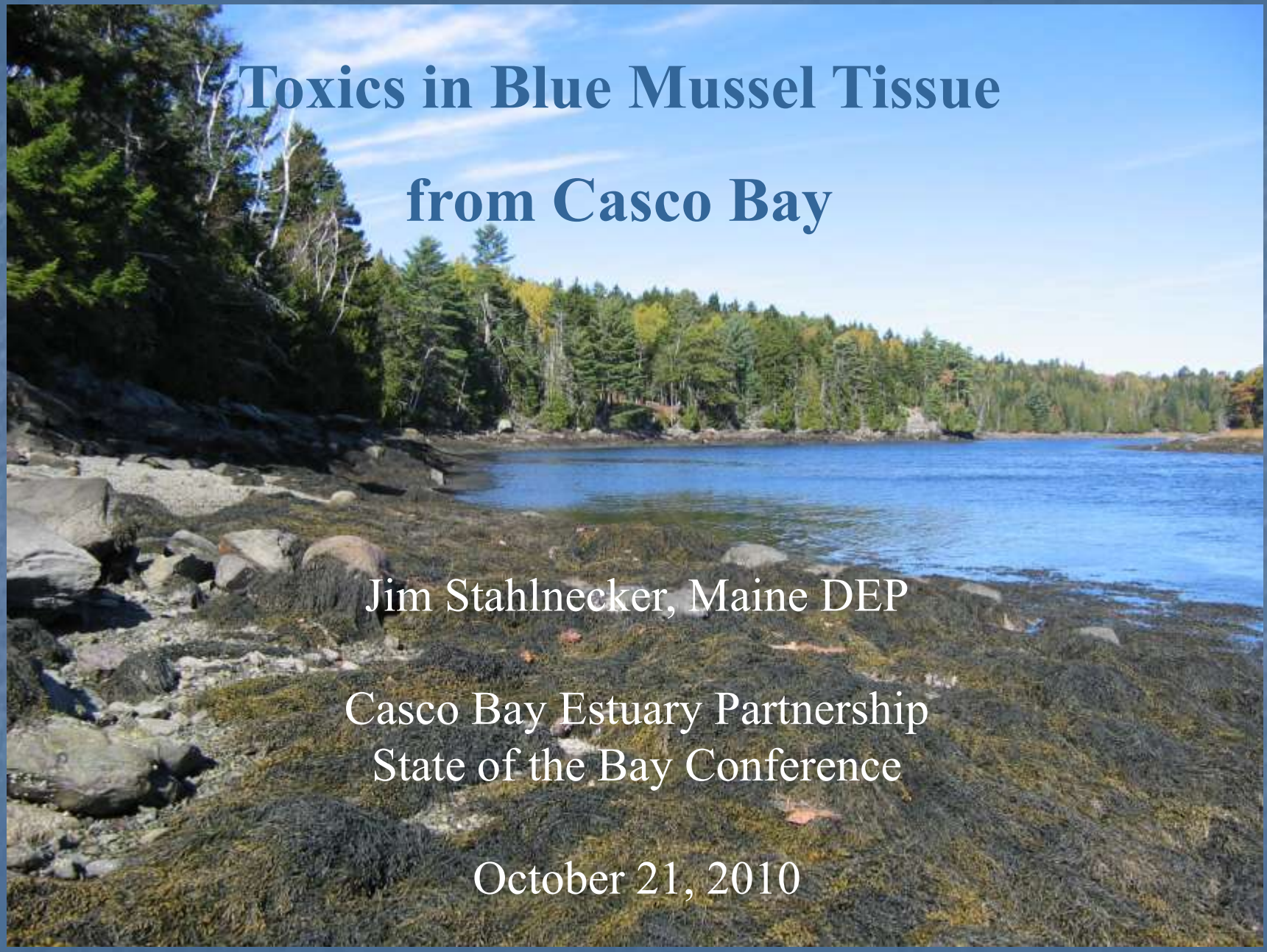


# Toxics in Blue Mussel Tissue from Casco Bay

Jim Stahlnecker, Maine DEP

Casco Bay Estuary Partnership
State of the Bay Conference

October 21, 2010

# Why Mussels?

- UBIQUITOUS
- SEDENTARY
- “HITS” WHEN WATER YIELDS ND
- GEOGRAPHIC RANGE, COMPARABILITY
- SWAT, GULFWATCH, NATIONAL STATUS & TRENDS PROGRAMS
- DATA FOR MANY ANALYTES AVAILABLE

# *Mytilus edulis*

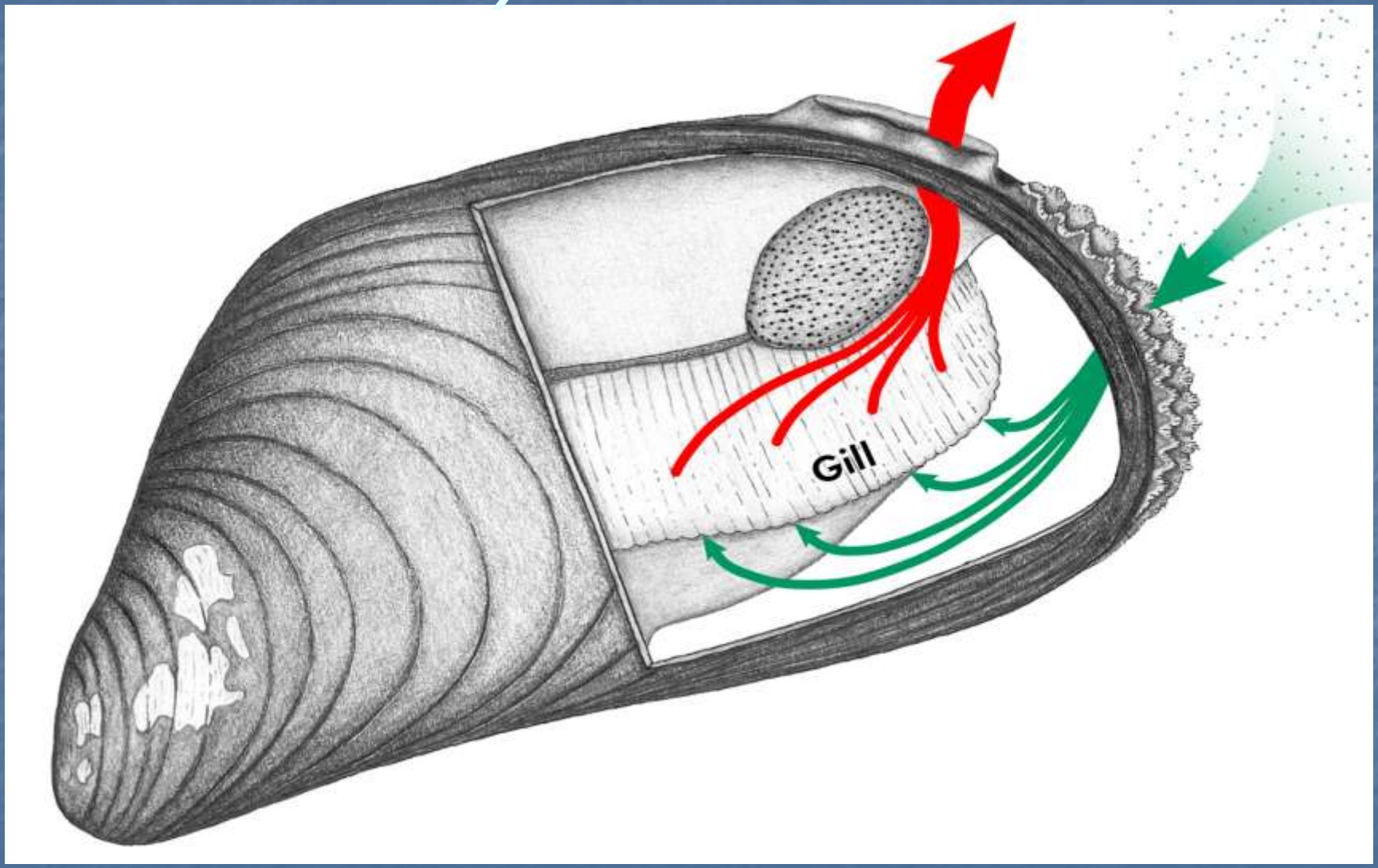



Illustration by Ethan Nedeau

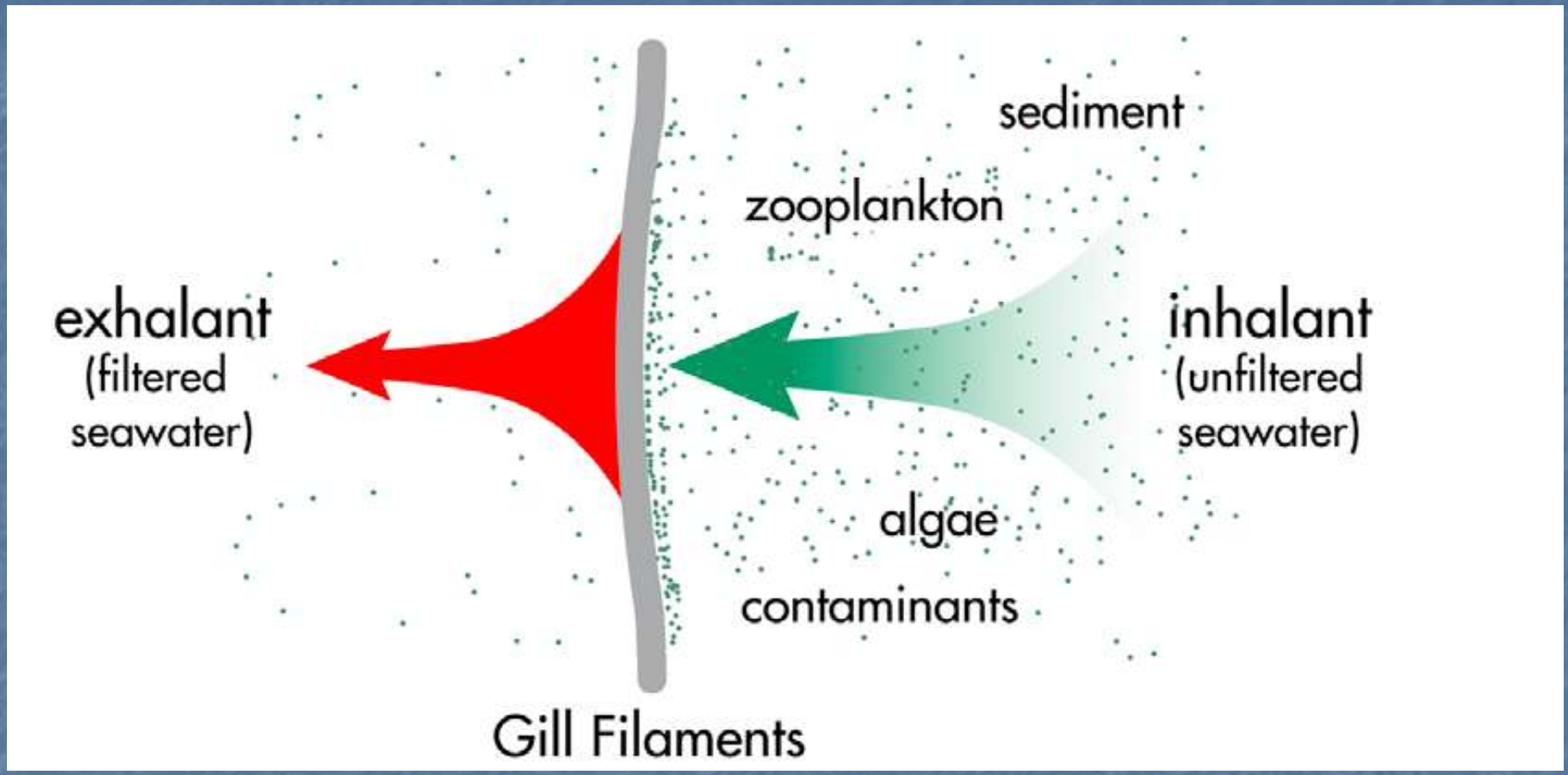
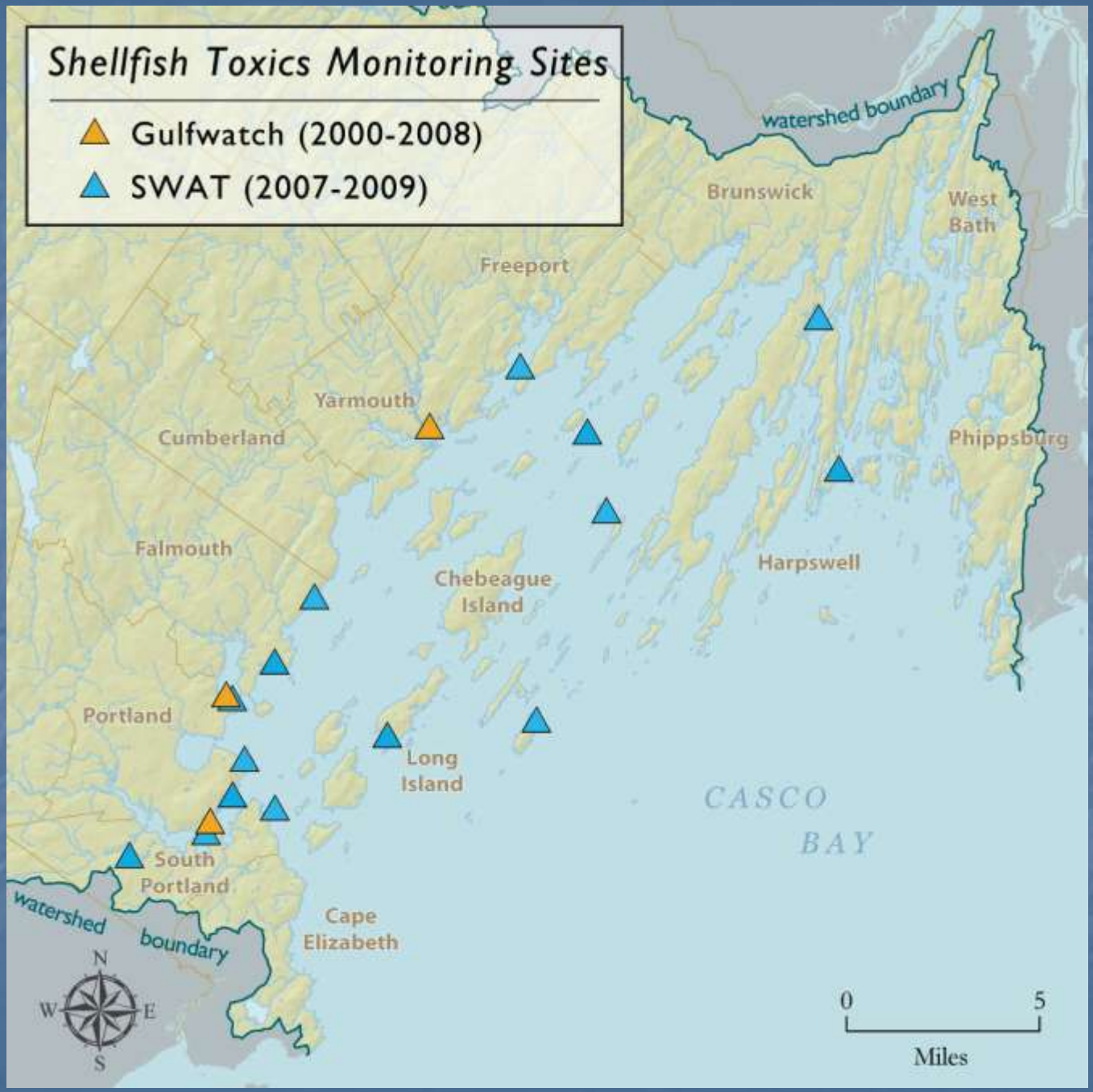



Illustration by Ethan Nedeau

# Statewide and GOM Monitoring History

- 1987 – Maine DEP begins using blue mussels as an indicator of toxic exposure
- DEP SWAT Program has 65+ stations statewide over 23 years
- CBEP/DEP collaboration on additional mussel sites in Casco Bay
- 1991 – Gulfwatch begins sampling across GOM in a joint US/Canadian monitoring program
- National Status and Trends Mussel Watch Program


Shellfish Toxics Monitoring Sites
Gulfwatch (2000-2008)
SWAT (2007-2009)
watershed boundary
Brunswick
West Bath
Freeport
Yarmouth
Cumberland
Phippsburg
Falmouth
Harpswell
Chebeague Island
Portland
Long Island
CASCO BAY
South Portland
Cape Elizabeth
watershed boundary
N
W
E
S
0
5
Miles

# Blue Mussel Sampling Protocol

- Mid-October to mid-December annually
- Four sub-locations at each station (mean)
- Mussel shell length 50-60 mm.
- Composited samples of 20 and 30 mussels per sub-location
- Analysis for 10 metals, PAHs, PCBs, pesticides, dioxins and furans

Semper *Mytilus*?

Semper Paratus

## Toxics Elevated[1,2] in Mussels Collected from Sampling Sites in Casco Bay 2007 – 2009
(Note that only East End Beach was sampled twice during this period)(DEP 2010)

| Year Sampled | Sampling Location | Al | Fe | Cr | Cu | Ni | Pb | Zn | Hg | PCBs[3] | PAHs[4] | Organo-chlorine Pesticides[5] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | Spring Point, S. Portland | | | | X[2] | | X[2] | | | | | X[2] |
| | Middle Fore River, S. Portland | | | | X[2] | | X[2] | X[1,2] | | X[2] | X[2] | X[2] |
| | East End Beach, Portland | | | | X[2] | | X[2] | | | | | X[2] |
| | Jewell Island, Punch Bowl | | | | | | | | | | | |
| | Falmouth Anchorage | | | | X[2] | | | | | | | |
| | Harraseeket River, Freeport | | | | X[2] | | | | | | | |
| | Mare Brook, Harpswell Cove | | | | X[2] | | | | | | | |
| 2008 | Presumspcot River, Falmouth | | | | X[2] | | X[1,2] | | X[2] | | | X[2] |
| | Middle Bay, Harpswell | | | | | | | | | | | |
| 2009 | Inner Fore River, Portland | X[1,2] | X[2] | X[1,2] | X[2] | X[2] | | | | X[2] | X[2] | X[2] |
| | East End Beach, Portland | X[1,2] | X[2] | X[1,2] | | X[2] | X[2] | | | X[2] | | X[2] |
| | Mill Creek, Falmouth | | | | | | | | | | | |
| | Long Island | | | | | | | | | | | X[2] |
| | Maquoit Bay Freeport | | | | | | | | | | | |
| | Quahog Bay, Harpswell | | | | | X[2] | | | | | | |

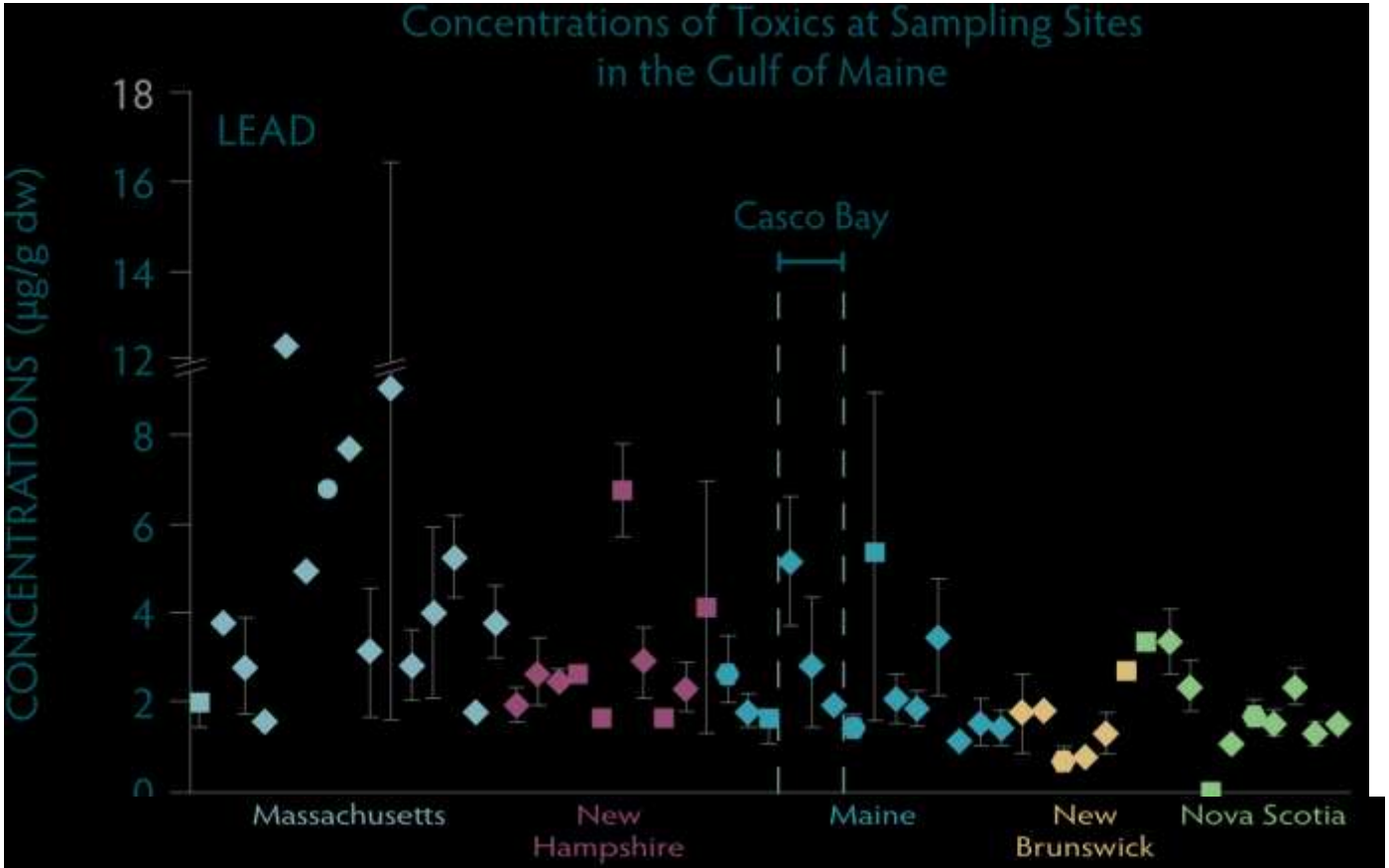
[1] Elevated based on Maine Reference Conditions, mean + 2 standard deviations (DEP 2005)
[2] Elevated based on Gulf of Maine-wide Gulfwatch 85th percentile value, *i.e.*, 85% of samples fall below the 85th percentile value (GOMC 2009)
[3] Sum of 19 PAHs
[4] Sum of 35 PCB congeners
[5] Sum of Organochlorine pesticides

# Status of Casco Bay Mussels Pesticides

- DDT in low range nationally (NS&T)
- Dieldrins/chlordanes in low range nationally (NS&T)
- Sum of organochlorine pesticides higher than GOM 85$^{th}$ percentile (Gulfwatch) at some Casco Bay stations
- 2009 SWAT analysis for organophosphates, triazines, pyrethroids and organonitrogens were at non-detect levels

# Status of Casco Bay Mussels Metals

- Al and Fe related to sediment ingestion
- Above Maine reference condition
  - Cr – Inner Fore River, East End Beach
  - Zn – Middle Fore River
  - Pb – Presumpscot River
- Above Gulfwatch 85$^{th}$ percentile
  - Additional sites exceed less rigorous standard for Cu, Ni, Pb, Hg and also for PCBs, PAHs
- Concentrated in the western portion of the bay

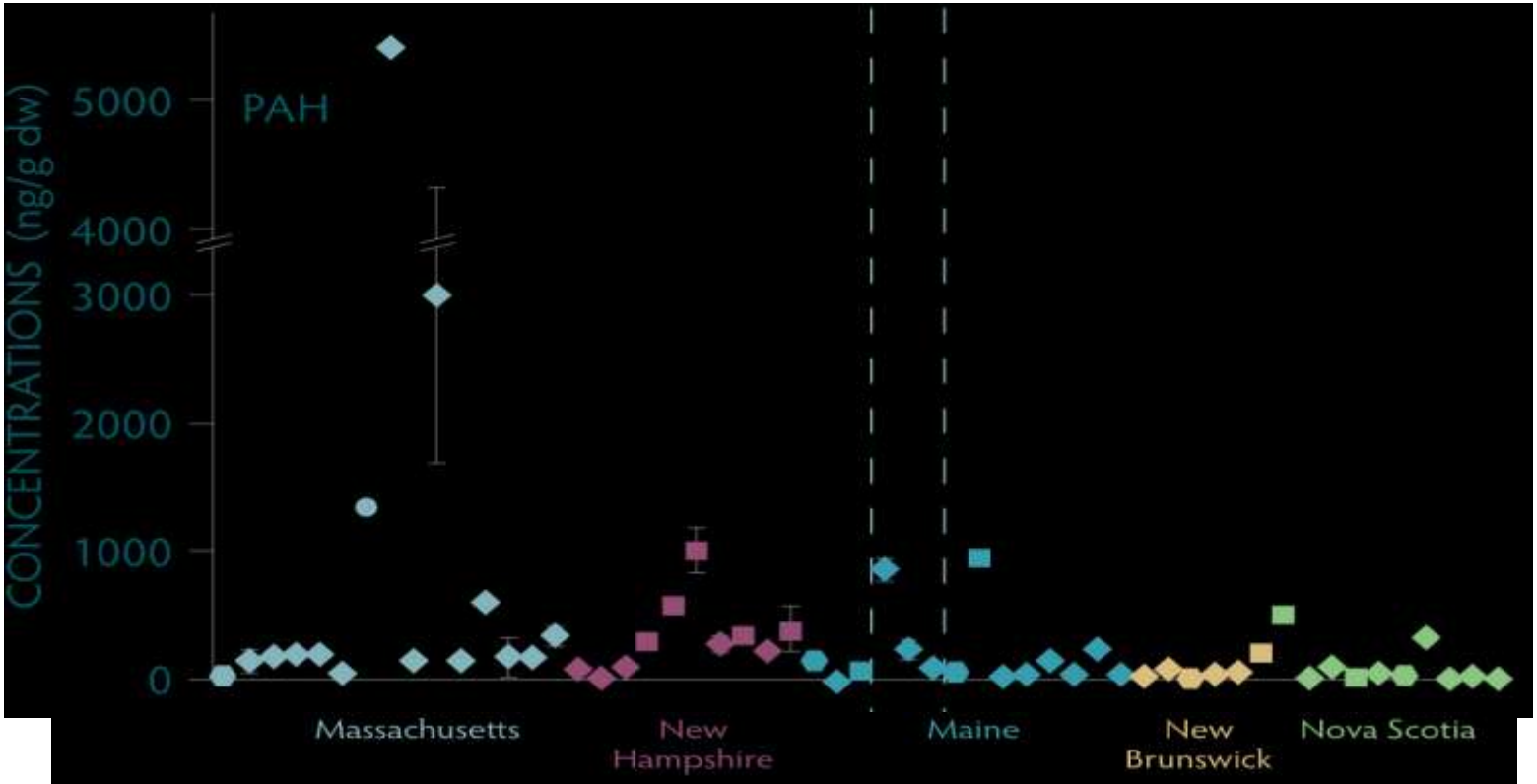



Eight-year (2000-2008) median and median absolute deviations[1] in concentrations in mussel tissues at all Gulfwatch sites, in geographic order (south to north along the x axis from Massachusetts to Nova Scotia).

- Benchmark site (sampled every year)
- Multi-year sites (sampled every 3 years)
- Sampled every 6 years
- Occasionally sampled sites

[1] In statistics, the median absolute deviation (MAD) is defined as the median of the absolute deviations from the data's median: $MAD = \text{median}_i ( |X_i - \text{median}_j(X_j)| )$ In words, 50% of observations lie within the range defined by the MAD.

# Concentrations of Toxics at Sampling Sites in the Gulf of Maine

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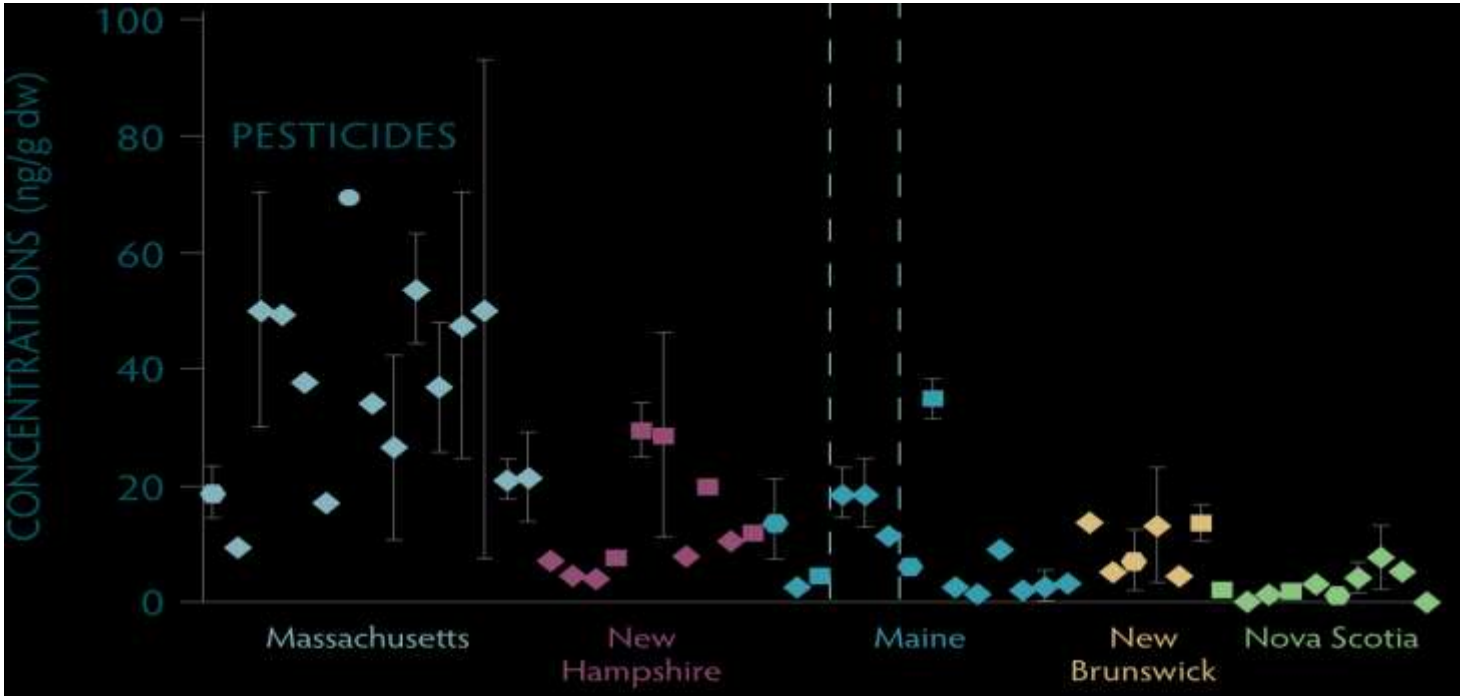


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In words, 50% of observations lie within the range defined by the MAD.

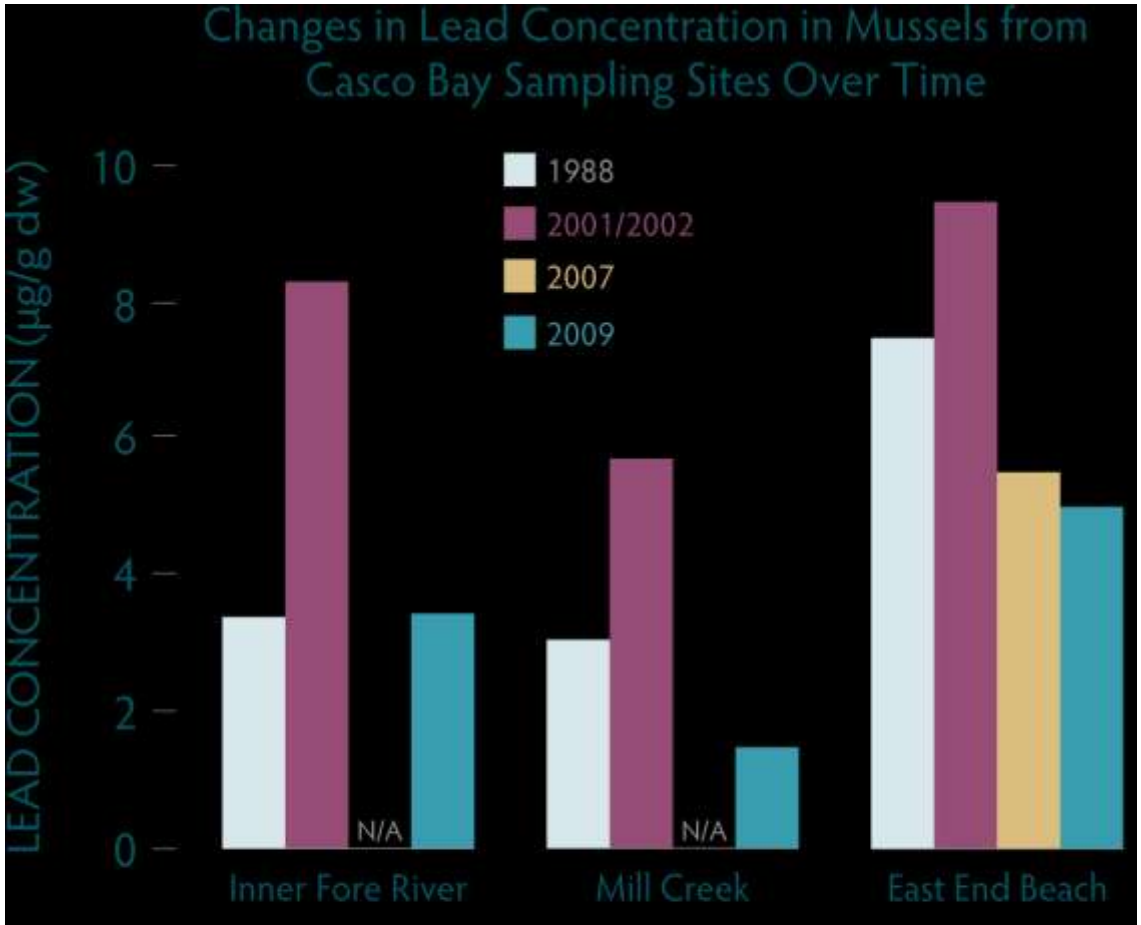
# Trends in Toxics in Casco Bay and the Gulf of Maine

- Most metals appear to be declining (Pb) or remaining stable in time gulfwide
- Pb and some metals appear to be declining at Portland Harbor (2000-08)
- Σ24 PAHs elevated but appear stable in Portland Harbor (vs. 1993-2001)
- Chlorinated pesticides and PCBs show S to N regional trend, with highest Casco Bay levels at Portland Harbor

## Gulfwatch Data for Metals in Portland Harbor

| Year | Hg | Ag | Cd | Pb | Ni | Zn | Al | Cr | Fe | Cu |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | 0.1 | 1.78 | 11.5 | 2.45 | 357.5 | 370 | 2.3 | 737.5 | 12.3 |
| 2003 | 0.30 | 0.09 | 1.48 | 2.33 | 7.62 | 107.8 | 467 | | 668.8 | |
| 2005 | 0.29 | 0.05 | 1.89 | 6.58 | 1.39 | 159.5 | 464 | 1.8 | 761.3 | 8.6 |
| 2007 | 0.2 | 0.02 | 1.39 | 4.34 | 0.95 | 146 | 250 | 1.7 | 444 | 7.6 |
| 2008 | 0.2 | 0.02 | 1.48 | 5.16 | 1.06 | 139 | 483 | 1.4 | 606 | 8.08 |

Most metals have decreased over time (units are µg/g dry weight).




DEP SWAT sampling over time at several Casco Bay sites suggests that while there was an initial increase in lead levels from 1988 to 2001/2002, there has been a decline in lead levels in more recent samples. Units are micrograms per gram dry weight. The Gulfwatch mussel sampling program (see table below) has observed a regional decline in lead levels over the past decade.

# Conclusions

- Locations away from concentrated human activity have measurable but not elevated levels of toxics, in Casco Bay and in GOM
- Locations with elevated toxics:
  - Past manufacturing, pollutants in sediment
  - Harbors and commercial port areas
  - Mouths of rivers
  - Developed areas with runoff from impervious surfaces

# Example:  Inner Fore River

- Historical upstream industry
- Stroudwater River input
- Runoff from Jetport, Maine Mall

# Example:  East End Beach

- Urban runoff
- Dense residential development
- Dump leachate
- Presumpscot River input

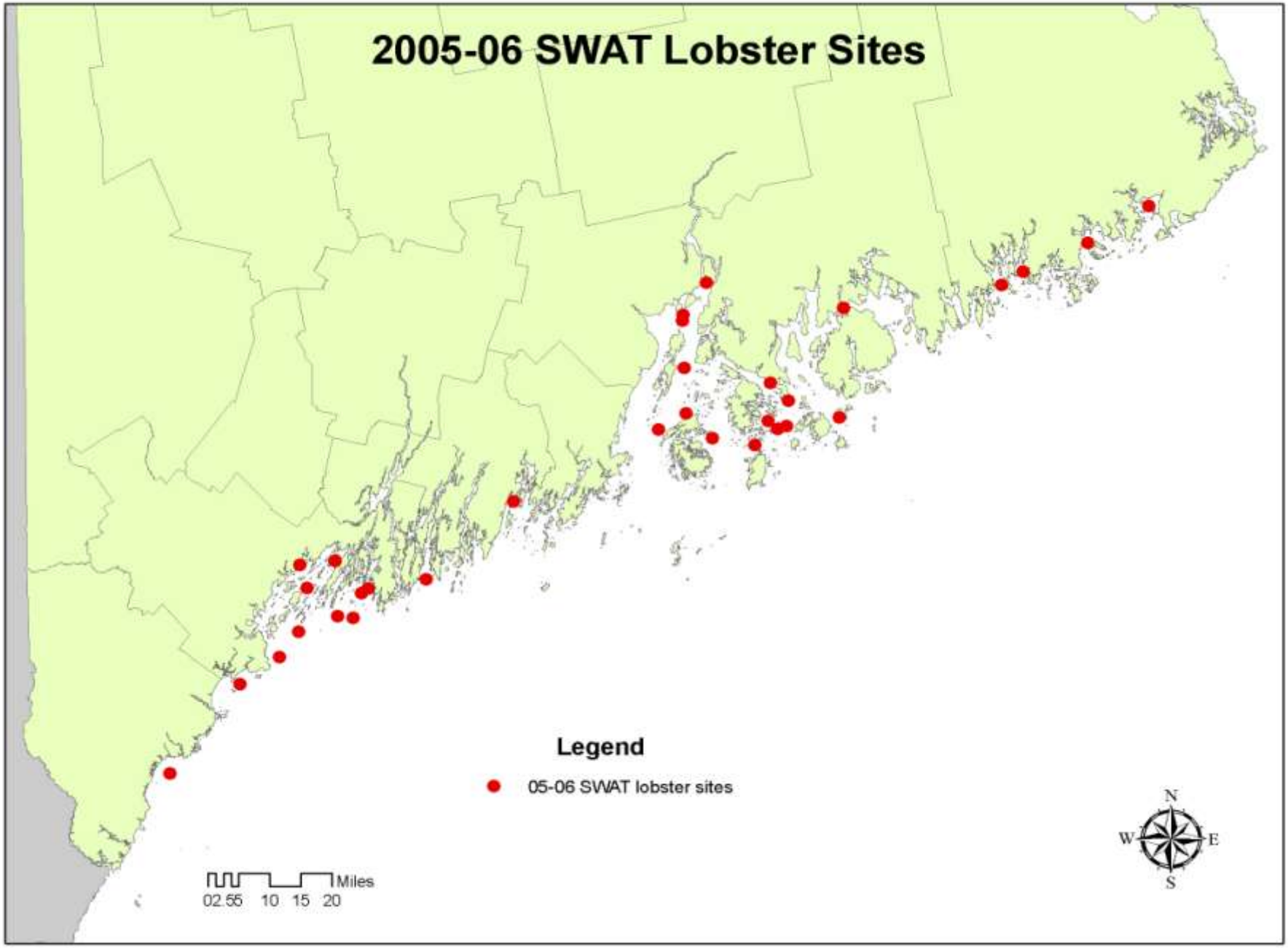
# A Consistent Pattern

- Toxics vary with human activity patterns
  - DEP SWAT data – statewide, within Casco Bay
  - Gulfwatch data – gulfwide, within Casco Bay
  - National Status and Trends data – nationally
  - State of the Bay Indicator 10 – sediment data

# How beautiful on the mountains are the feet of those who bring good news…

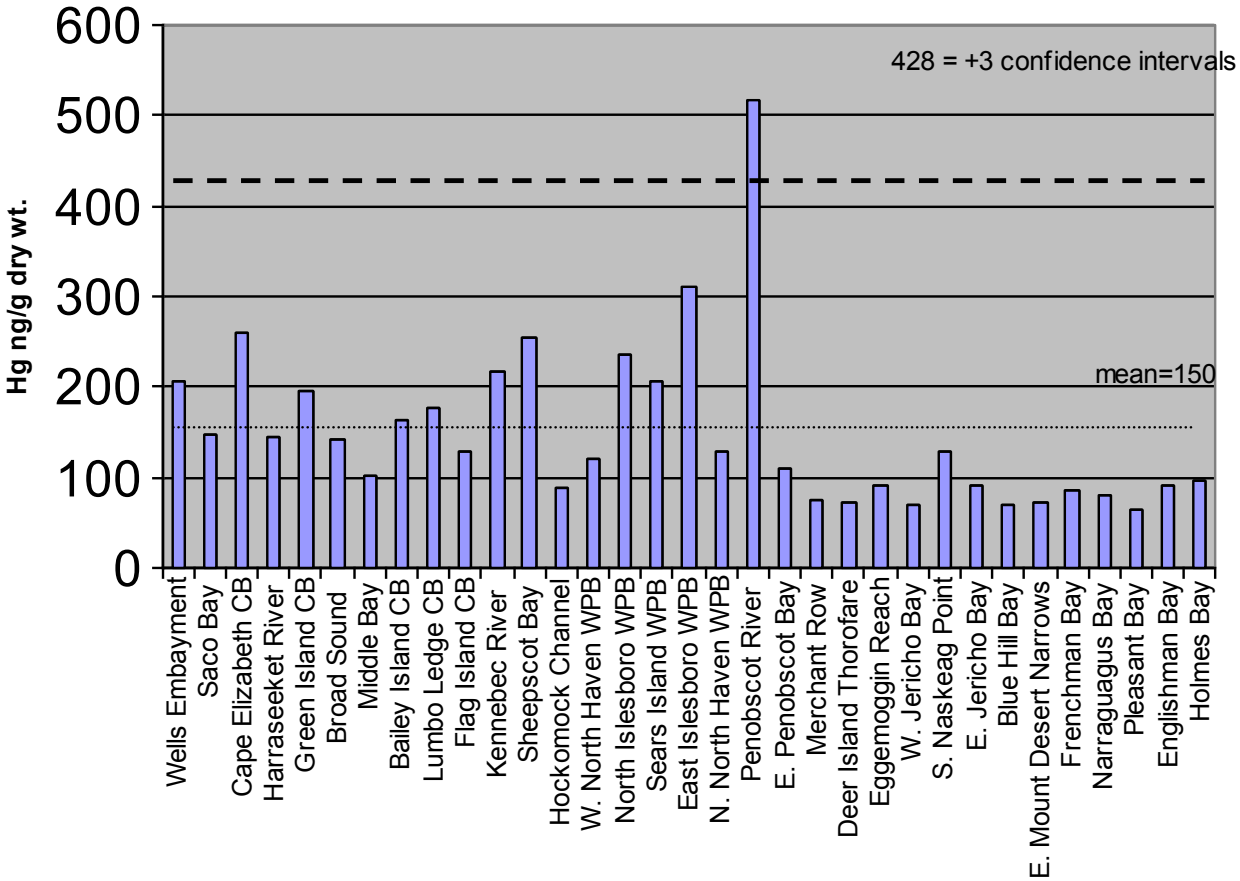
- Gulfwatch data suggest metals levels have decreased across the Gulf of Maine and in Casco Bay
- DEP SWAT data also suggest that Pb levels have decreased at several Casco Bay sites


DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OF MAINE

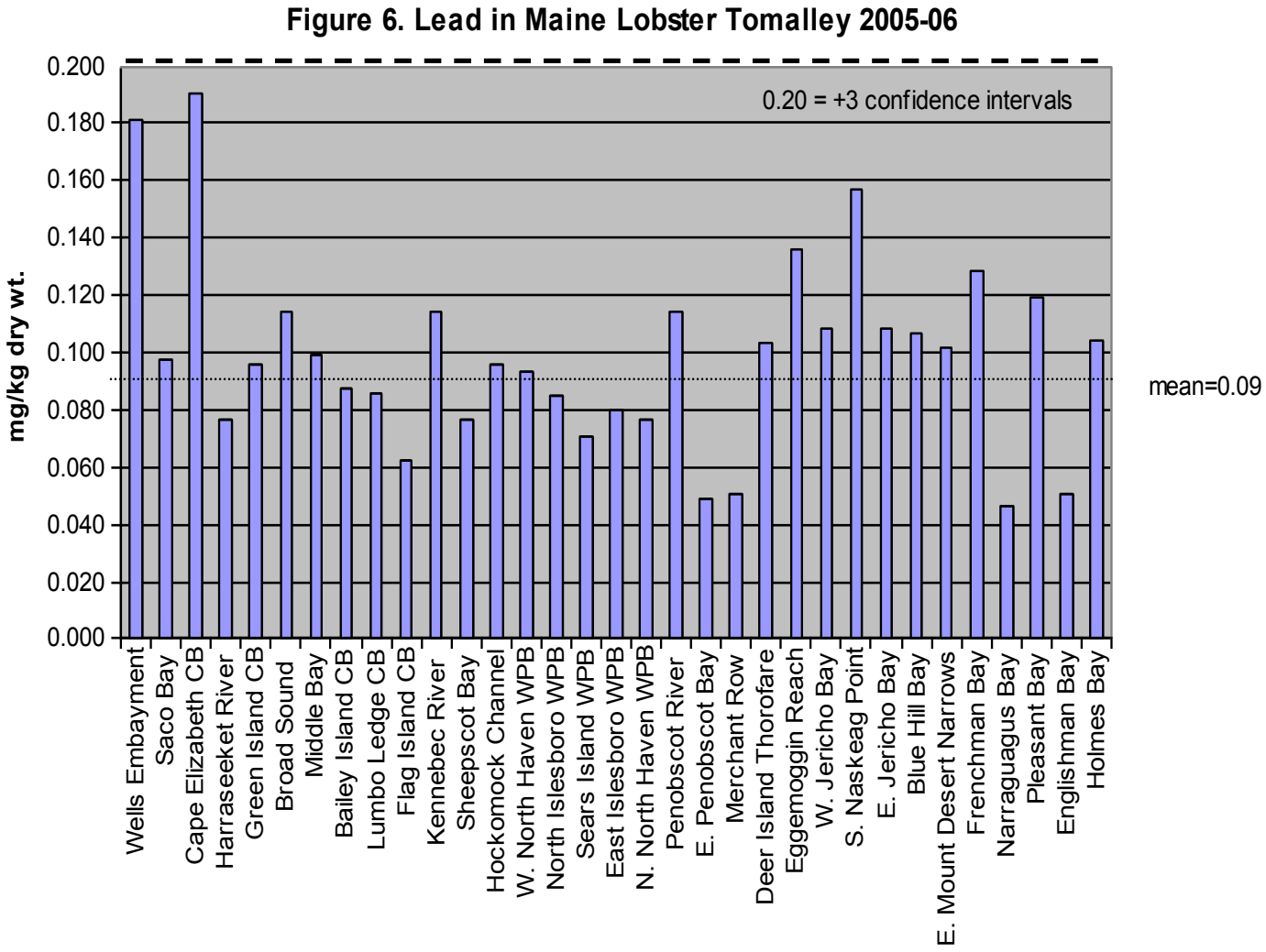

2005-06 SWAT Lobster Sites
Legend
05-06 SWAT lobster sites
Miles
0 2.5 5 10 15 20
N
W
E
S

# Hg in LOBSTER TOMALLEY

**Figure 2. Mercury in Maine Lobster Tomalley 2005-06**

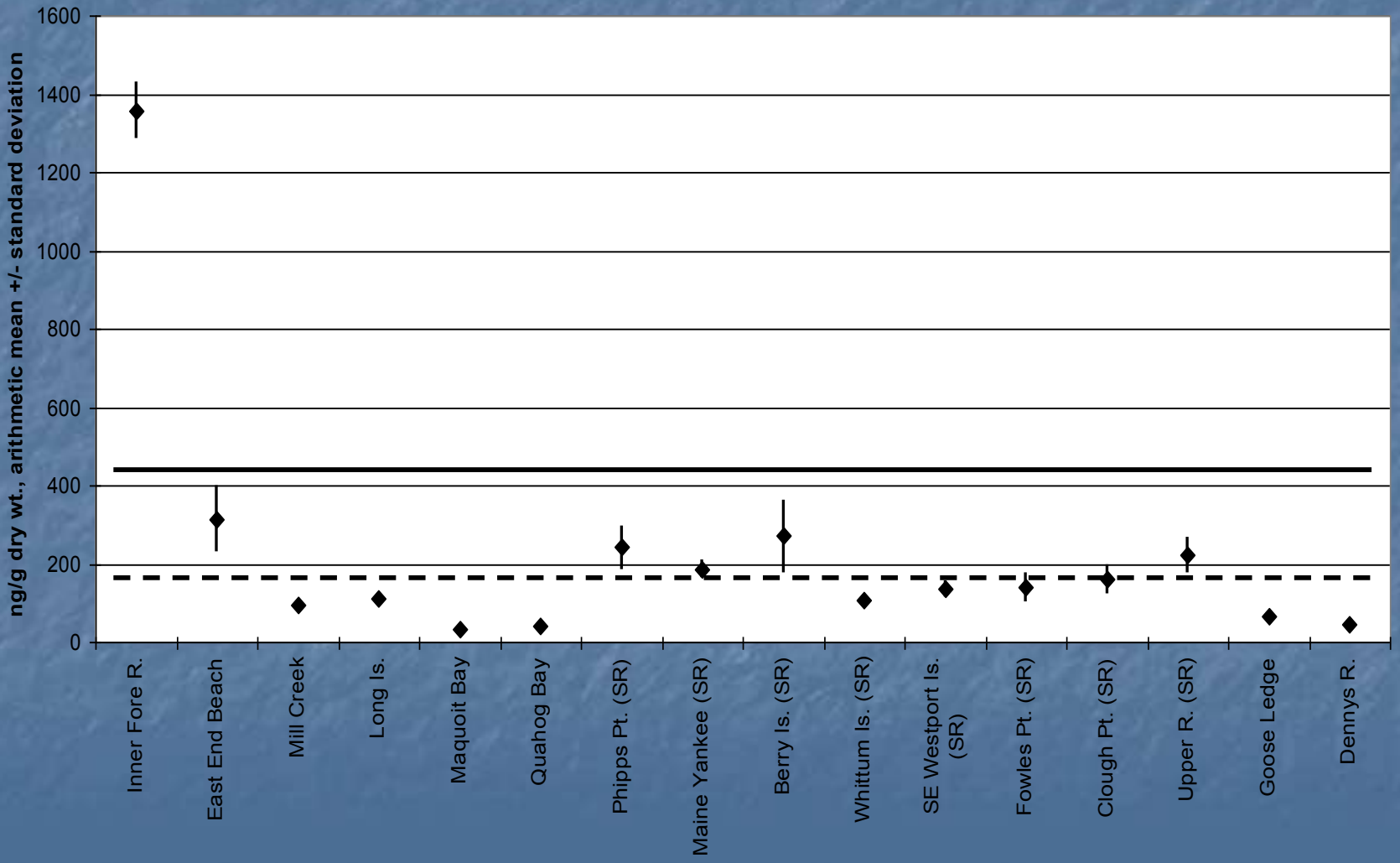


# Pb in LOBSTER TOMALLEY



# 2009: 19 VS. GULFWATCH

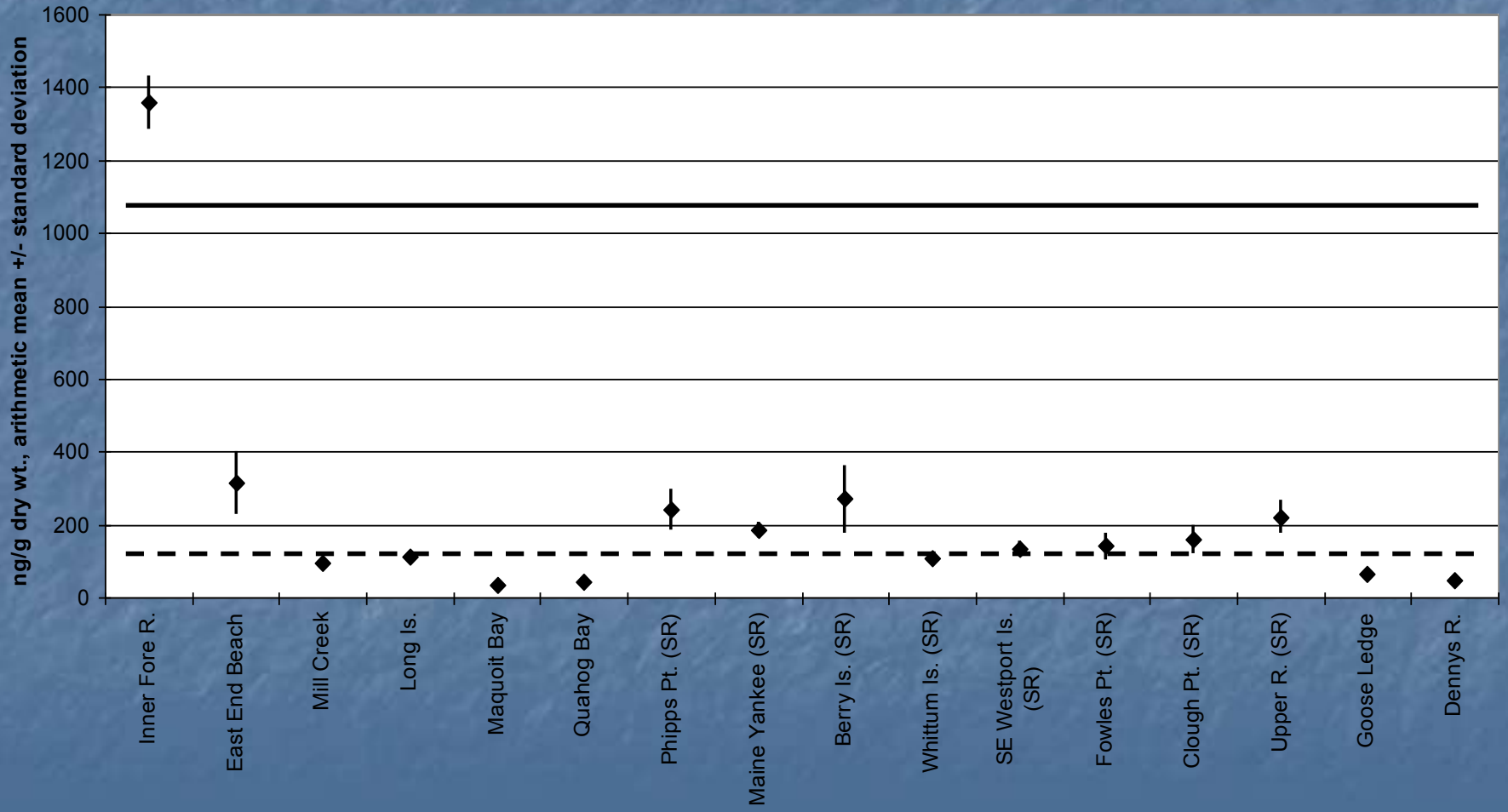
**Figure 1.1.3.2.2: Sum of 19 PAHs in 2009 SWAT Blue Mussels**




**Dashed line = 2008 Gulfwatch Median (Sum 19 PAHs); Solid line = 2008 Gulfwatch 85th Percentile (Sum 19 PAHs).**

# 2009: 19 VS. NS&T

**Figure 1.1.3.2.3: Sum of 19 PAHs in 2009 SWAT Blue Mussels**




**Dashed line = 2008 National Status and Trends Median (Sum 19 PAHs); Solid line = 2008 National Status and Trends 85th Percentile (Sum 19 PAHs).**

# FLU+PYR/Σ(FP + C2-C4-P)